Federal Board SSC-II Examination
SLOs Based Annual Question Paper
PHYSICS (SSC-II) 10th
(Annual Paper 2023) Version No. 6073

SECTION – A (Marks 12)

Q1. Fill the relevant bubble against each question according to curriculum:

1. In computer terminology processed data is called:

A. Information ○ B. Procedure ○
C. Output ○ D. Input ○

2. What happens to the atomic number of a radioactive element which emits one alpha and one beta particle?

A. Decrease by 2 ○ B. Decrease by 1 ○
C. Increases by 1 ○ D. Stays the same ○

3. If the frequency of a wave is doubled, then the time period of the wave will:

A. Decrease to half ○ B. Decrease to quarter ○
C. Become double ○ D. Remain the same ○

4. The intensity level of faintest audible sound is:

A. 20 db ○ C. 30 db ○
C. 0 db ○ D. 10 db ○

5. Which of the following shows correct relationship among v, f and λ?

A. $v = \frac{\lambda}{f}$ ○ B. $f = \frac{\lambda}{v}$ ○
C. $v = \frac{f}{\lambda}$ ○ D. $f = \frac{v}{\lambda}$ ○

6. The focal length of a convex mirror with radius of curvature 10 cm is:

A. +5 cm ○ B. −5 cm ○
C. +10 cm ○ D. −10 cm ○

7. If a ray of light makes an angle of incidence 45° on a plane mirror, the angle of reflection will be:

A. 15° ○ B. 135° ○
C. 45° ○ D. 90° ○

8. The Coulomb's force between two identical charges is 100 N. If the distance between the charges is doubled, then the force will be:

A. 50 N ○ B. 200 N ○
C. 20 N ○ D. 25 N ○

9. Which of the following represents one ohm?

A. WA^{-1} ○ B. JC^{-1} ○
C. VA^{-1} ○ D. JS^{-1} ○

10. Which of the following quantities remains constant in step up transformer?

A. Heat ○ B. Voltage ○
C. Current ○ D. Power ○

11. A and B are the two inputs of a NOR gate. Its output would be 1 when:

A. $A = 0, B = 1$ ○ B. $A = 0, B = 0$ ○
C. $A = 1, B = 1$ ○ D. $A = 1, B = 0$ ○

12. The output of NAND gate is written as:

A. $X = A - B$ ○ B. $X = \overline{A.B}$ ○
C. $X = A + B$ ○ D. $X = A.B$ ○

SECTION – B (Marks 33)

Q2. Answer any ELEVEN parts from the following. All parts carry equal marks. **(11 × 3 = 33)**

(i) At one end of a ripple tank 80 cm across, a 5 Hz vibrator produces waves whose wavelength is 40 mm . Find the time the waves need to cross the tank.

Ans:

- **Given data:**

Length $= d = 80\ \text{cm} = \frac{80}{100} = 0.8\ \text{m}$; Frequency $= f = 5\ \text{Hz}$

Wavelength $= \lambda = 40\ \text{mm} = \frac{40}{1000} = 0.04\ \text{m}$

- **Required:**

Time $= t = ?$

- **Solution:**

$\Rightarrow \quad v = f\lambda = 5\ \text{Hz} \times 0.04\ \text{m} = 0.2\ \text{ms}^{-1}$

The formula for wave speed is: $\text{Wave speed}\ (v) = \frac{d}{t} \quad \Rightarrow \quad t = \frac{d}{v} \quad \ldots\ldots\ldots\ldots (1)$

$\Rightarrow \quad t = \frac{0.8\ \text{m}}{0.2\ \text{ms}^{-1}} \quad \Rightarrow \quad t = 4\ s$

(ii) Waves are means of energy transfer without transfer of matter. Comment.

Ans: Waves enable the transfer of energy without the physical displacement of matter. Whether mechanical waves, like sound, or electromagnetic waves, like light, propagate through a medium or vacuum, respectively, they carry energy through oscillations without permanently transporting the medium's particles. This characteristic distinguishes waves from material transport mechanisms, highlighting their role as efficient energy carriers.

OR(Second Answer)

A wave allows energy and information to be transferred from one point to another without any particles of the medium travelling between the points. It transport energy without the transfer of matter through which a wave travels. For example when we shake the stretched string up and down, we provide our muscular energy to the string. As a result a set of waves can be seen travelling along the string. The vibrating force from the hand disturbs the particles of the string **and** set them in motion. These particles then transfer their energy to the adjacent particles in the string. Energy is thus transferred from one point of the medium to another in the form of waves. It is the disturbance that travels in a **wave,** transferring energy.

(iii) Why is sound produced by a simple pendulum not audible by human ear?

Ans: The frequency of vibrations produced by a pendulum does not fall under human ear's audible range, so we do not hear the sound produced due to these vibrations. The membrane of human ear can be vibrated by those sounds whose frequency is greater than 20 Hz and below than 20,000 Hz. Now we know that, the frequency of waves produced by a simple pendulum is below 20 Hz, so such waves cannot vibrate the membrane of our ear and thus we cannot hear such sound.

(iv) What is speed of sound in air at $-20°C$?

Ans:

- **Given data:** Temperature $T = -20°C$
- **Required:** **Speed of sound in air $= v = ?$**
- **Solution:** Speed of sound at any temperature "T" is given by: $v = 331 + 0.6\,T$

Putting values of "T": $v = 331 + 0.6 \times (-20) = 331 - 12 = 319\ \text{ms}^{-1}$

(v) What is meant by the term 'total internal reflection'? Explain briefly with ray diagram.

Ans: **Total Internal Reflection:**

The angle of incidence for which the angle of refraction becomes $90°$ is called critical angle. When the angle of incidence becomes larger than the critical angle, no refraction occurs. The entire light is reflected back into the denser medium. This is known as total internal reflection of light.

OR

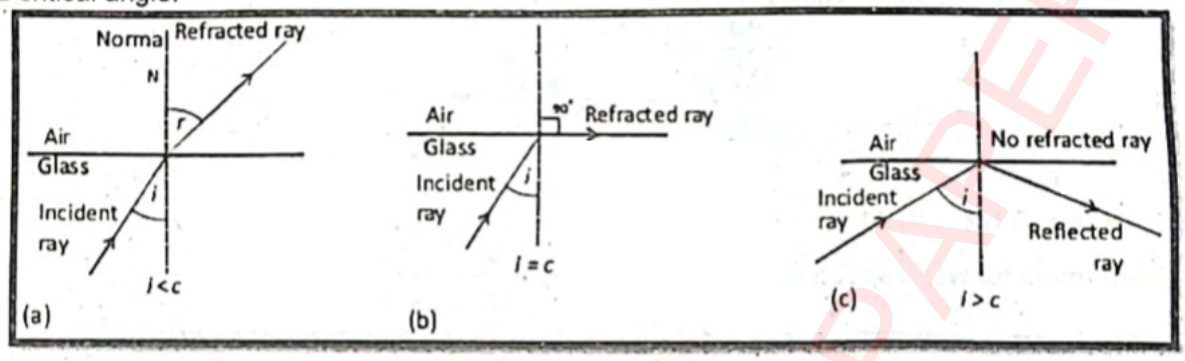
When the angle of incidence becomes larger than the critical angle, no refraction occurs. The entire light is reflected back into the denser medium. This is known as total internal reflection of light.

Explanation:

When a ray of light enters from a denser medium to a rarer medium it bends away from the normal. If the angle of incidence increases the angle of refraction also increases. For a particular value of the angle of incidence the angle of refraction becomes $90°$.

Critical Angle:

The angle of incidence that causes the refracted ray in the rarer medium to bend through $90°$ is called critical angle.



TOTAL INTERNAL REFLECTION

(vi) Light travels from crown glass ($n_g = 1.52$) into water ($n_w = 1.33$). The angle of incidence in crown glass is $40°$. What is angle of refraction in water?

Ans:

- **Given data:**

  Refractive index of crown glass $= n_g = 1.52$; Refractive index of water $= n_w = 1.33$

  Angle of incidence $= \theta_i = 40°$

- **Required:**

  Angle of refraction in water $= \theta_r = ?$

- **Solution:**

  Using formula of Snell's law,

$$\Rightarrow \quad n_g = \sin\theta_i = n_w = \sin\theta_r$$

$$\Rightarrow \quad \frac{n_g}{n_w} = \frac{\sin\theta_r}{\sin\theta_i} \qquad \Rightarrow \quad \frac{1.52}{1.33} = \frac{\sin\theta_r}{\sin 40°}$$

$$\Rightarrow \quad \sin\theta_r = \sin 40° \times \frac{1.52}{1.33} \qquad \Rightarrow \quad \sin\theta_r = 0.642 \times 1.142$$

$$\Rightarrow \quad \sin\theta_r = 0.7331 \qquad \Rightarrow \quad \theta_r = \sin^{-1}(0.7331) \qquad \Rightarrow \quad \theta = 47.14°$$

Hence, the angle of refraction in water is $47.14°$.

(vii) Prove that potential difference can be described as energy transfer per unit charge between the two points.

Ans: **Potential difference as energy transfer:**

Consider "W" amount of work is done on a charge "q" in bringing it form infinity to a point inside the field, then electric potential at that point will be given by:

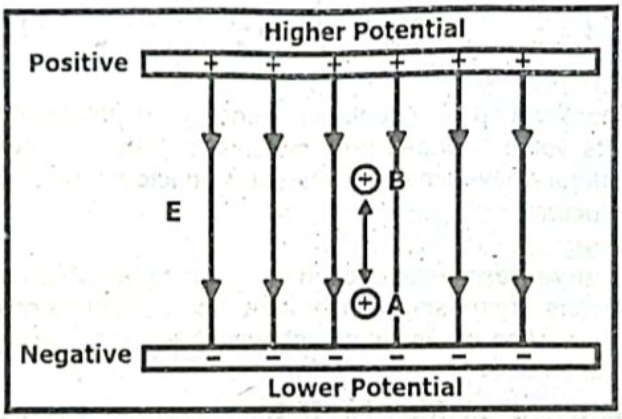
$$V = \frac{W}{q} \qquad \ldots\ldots\ldots(1)$$

This work done is stored in the charge in form of potential energy, called potential energy (U). Therefore, the above equation can also be written as:

$$V = \frac{W}{q} = \frac{U}{q} \qquad \ldots\ldots\ldots(2)$$

Electric potential is a scalar quantity unlike electrostatic force and electric field intensity. It has only magnitude which is given by equation (2).

Consider a positive test charge "+q" is located inside a field at point "A" as shown in the figure below. The charge will have electric potential at points "A" and "B" because both the points are inside the field.



ELECTRIC POTENTIAL

To move this charge from point "A" to point "B", work has to be done. This work done per unit charge will give potential difference between points "A" and "B" given by:

If point "A" is taken at infinity, i.e., the point where there is no potential, then equation (2) will reduce to equation (1) and will give electric potential at point B;

$$\Delta V = V_B - V_A \quad \frac{W_{A\ to\ B}}{q} \qquad \ldots\ldots\ldots (3)$$

$$\Rightarrow \quad V_B - 0 = \frac{W_{\infty\ to\ B}}{q} \quad \Rightarrow \quad V_B = \frac{W}{q}$$

In summary, the relationship between potential difference (or voltage) and electrical potential energy is given by: $\Delta V = \frac{\Delta PE}{q}$ and $\Delta PE = q\Delta V$

(viii) What is meant by electric field? Also describe electric field intensity briefly.

Ans: **Electric Field:**

The region around a charge where it can attract or repel another charge, when brought to that region is called electric field.

Electric fields are usually caused by varying magnetic fields or electric charges. Electric field strength is measured in the SI unit volt per metre (V/m).

Electric Field Intensity:

The space around an electric charge in which its influence can be felt is known as the electric field. The electric field intensity at a point is the force experienced by a unit of positive charge placed at that point. Electric field intensity is a vector quantity.

The electrostatic force per unit test charge (unit positive $q_o = +1C$) when it is brought to the electric field of a source charge is called electric field intensity.

$$\vec{E} = \frac{\overrightarrow{F_E}}{q_o} \qquad \ldots\ldots\ldots\ldots (1)$$

Equation (1) gives the equation for electric field intensity. Its S.I unit is NC^{-1}.

(ix) Briefly explain the factors on which resistance of a metallic conductor depends.

Ans: **Factors affecting Resistance:**

1. **Length of the wire:**

Greater the length of a conductor (wire), greater will be its resistance i.e., resistance is directly proportional to length. Mathematically:

$$R \propto L \qquad \ldots\ldots\ldots\ldots (1)$$

2. **Cross sectional Area of wire:**

Greater the cross-sectional area of a conductor (wire), smaller will be its resistance. i.e., resistance is inversely proportional to cross-sectional area. Mathematically:

$$R \propto \frac{1}{A} \qquad \ldots\ldots\ldots\ldots (2)$$

Combining proportionalities in equation 1 and equation 2, we get:

$$R \propto \frac{L}{A} \quad \Rightarrow \quad R = \rho \frac{L}{A} \qquad \ldots\ldots\ldots\ldots (3)$$

3. **Material nature of wire:**
The proportionality constant (ρ) in equation (3) shows the nature of material called resistivity or specific resistance. Its value changes from material to material. Usually, insulators have greater resistivity while conductors have smaller. Different conductors have different resistivities depending upon their internal structure.

4. **Temperature of wire:**
By increasing temperature, resistance of conductors increases while that of insulators decreases. It is because in conductors, increasing temperature increases collisions of free electrons and thus resistance increases. In case of insulators, increasing temperature will increase conductivity and decrease temperature.

(x) A light bulb is switched on for 40 s. If the electrical energy consumed by the bulb during this times is 2400 J, find power of the bulb.

Ans:

- **Given data:**
  Time = $t = 40\ s$; Electric energy = $w = 2400\ J$
- **Required:**
  Power of the bulb = $P = ?$
- **Solution:**

$$\text{Power} = \frac{\text{Electric energy}}{\text{time}} = \frac{w}{t} = \frac{2400}{40} = 60\ W$$

(xi) How can the polarity of current carrying solenoid be found? Write briefly.

Ans: A long cylindrical coil consisting of a large number of turns of an insulated wire is called a solenoid. By the use of the right-hand grip rule, the polarity of a current-carrying solenoid (at the two ends) can be predicted. When we hold the solenoid in our right hand thus, the curl figures curl around it in the direction of current flow and the thumb indicates the north pole of the magnet.

We can determine the polarity of a solenoid by using Clock Rule. Look at the face of loop, if the current around that face is in anticlockwise direction, the face has the north polarity while if the current at that face is in clockwise direction, the face has the South polarity.

(xii) Which factors can affect the magnitude of induced e.m.f?

Ans: **Factors Affecting Induced e.m.f:**
The magnitude of induced e.m.f. in a circuit depends on the following factors:

1. Speed of relative motion of the coil and the magnet.
2. Number of turns of the coil.
3. Amount of current passing through the coil.

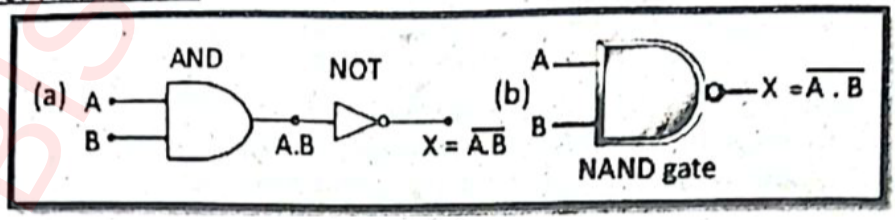
(xiii) Describe NAND gate and draw its symbol along with truth table.

Ans: **Formation of NAND GATE:**
The combination of AND gate with NOT gate is called NAND gate. A NAND gate as an AND gate with a NOT gate at its output.

The symbol for a NAND gate is made from an AND gate with the inversion circle (bubble) at its output as shown in figure below.

The logic equation for the NAND gate is written $X = \overline{A \cdot B}$ **(Read as X equals not A and B).** From truth table we can see that the output is low **(0)** when both inputs A and B are high **(1)** otherwise output is low **(0)**.

➢ **Symbol of NAND Gate:**



➢ **Truth table for NAND Gate:**

A	B	A.B	Out put = X = $\overline{A.B}$
0	0	$0.0 = 0$	$\bar{0} = 1$
0	1	$0.1 = 0$	$\bar{0} = 1$
1	0	$1.0 = 0$	$\bar{0} = 1$
1	1	$1.1 = 1$	$\bar{1} = 0$

(xiv) Why optical fibre is used for communication purpose?

Ans: Optical fiber is more useful tool for the communication processes for the following reasons. Optical fibers transmit information over large distances via light, with minimum loss of energy.

- They have high bandwidth over large distances.
- These optical fibers can easily be installed in houses or in offices as they occupy less space because of their small diameter.
- Fiber optic cables are immune to Electromagnetic interference and produce no interference while operating.
- There is no fire hazard while using optical fibers because light is transmitted through them.
- They are cheaper than ordinary copper wires.

Optical fibers are ideal for high-speed communication because they use light to transmit information, which can travel at an incredibly fast speed.

(xv) Cobalt-60 is a radioactive elements with half life of 5.25 years. What fraction of the original sample will be left after 26 years?

Ans: Half Life of Cobalt $- 60 = 5.25$ years

Time observed $= t = 26$ years

Remaining fraction of original radioactive isotope $= ?$

Number of Half Lives for sample $= \frac{26}{5.25} \approx 5$

If N_0 is a orignal fraction then after 5 half lives:

Remaining atoms $=$ Original atoms $\times 1/2^t$

$N = N_0 \times 1/2^t$

Or $N = N_0 \times 1/2^5$

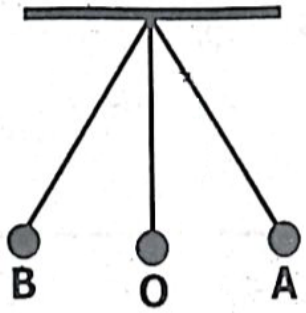
$\frac{N}{N_0} = \frac{1}{32}$

Hence, $\frac{1}{32}$ th of the original sample will be left.

SECTION – C (Marks 20)

Note: Attempt any TWO questions. All questions carry equal marks. **(2 × 10 = 20)**

Q3. a. A simple pendulum is displaced from mean position as shown in figure.



(i) Draw forces acting on it at point A and B.

(ii) Which forces is providing restoring force? Explain.

(iii) What will be the velocity of the bob at point A? Explain.

Ans:

(i) Forces acting on it at point A and B:

$mg \sin\theta$ ..... (i)

$mg \cos\theta$ ..... (ii)

Rectangular components of the weight:

At point "A" and "B", weight of the bob is divided into rectangular components "$mg\cos\theta$" and "$mg\sin\theta$".

The tension in the string cancels the $mg\cos\theta$ component of the weight given by: $T = mg\cos\theta$

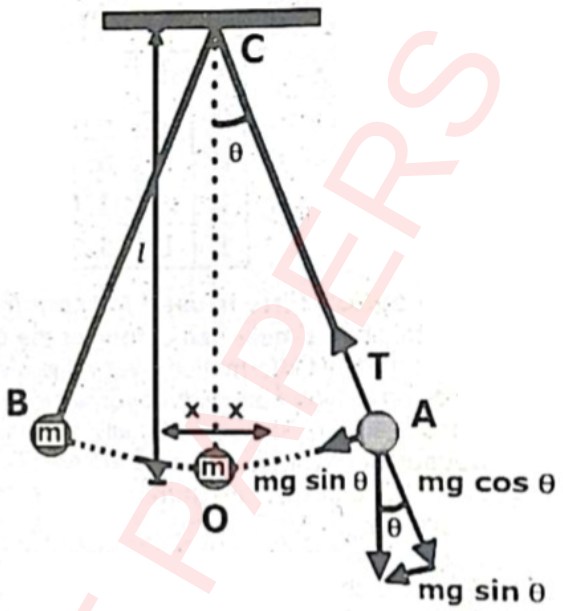
(ii) Forces providing restoring force:

The restoring force is only provided by "$mg\sin\theta$" component given by: $F_{res} = -mg\sin\theta$

The negative sign is there, because the restoring force tends to decrease displacement or we can say that the restoring force is directed towards mean position.

(iii) Velocity of the bob at point A:

The velocity will be maximum when it reaches mean position (O) and it will be zero when it reaches the extreme position "A" or "B".



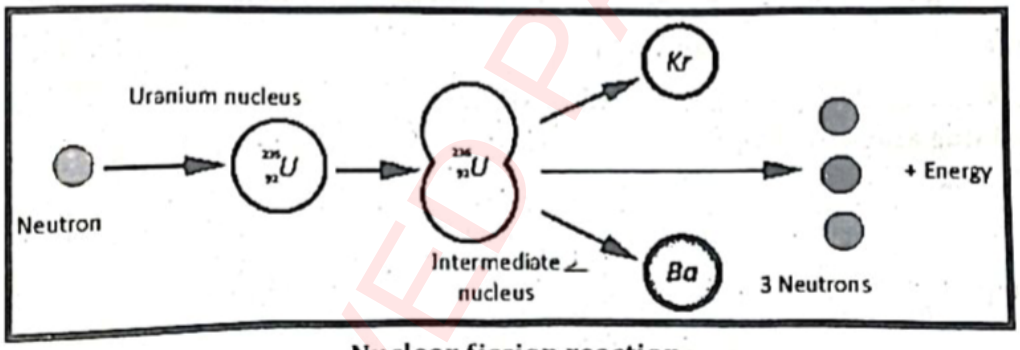
b. Describe the process of fission chain reaction.

Ans: Fission Chain Reaction:

A process in which a heavy nucleus breaks into two nearly equal parts with the release of large energy is called nuclear fission chain reaction.

Nuclear fission takes place when a heavy nucleus, such as U-235, splits, or fissions, into two smaller nuclei by absorbing a slow moving (low-energy) neutron as represented by the equation:

$$^{1}_{0}n + {}^{235}_{92}U \longrightarrow {}^{236}_{92}U^{*} \longrightarrow X + Y + \text{neutron}$$



Nuclear fission reaction

Fission Fragments:

Where U^{*}**-236** is an intermediate state that lasts only for a fraction of second before splitting into nuclei X and Y, called **fission fragments.** Nuclear fission was first observed in 1939 by Otto Hahn and Fritz Stresemann.

Fission Chain Reaction:

When a neutron reacts with a uranium nucleus, two or three neutrons are released. Every one of these reacts with next nuclei producing two or three more neutrons and hence, the number of available neutrons and the fission goes on increasing. Such a reaction is called the **chain reaction**.

On the average, **2.47** neutrons are released per event as represented by the expression.

$$^{1}_{0}n + {}^{235}_{92}U \longrightarrow {}^{141}_{56}Ba \longrightarrow {}^{92}_{36}Kr + 3\,{}^{1}_{0}n$$

In nuclear fission, the total mass of the products is less than the original mass of the heavy nucleus.

Q4. a. Derive the formula for the equivalent capacitance for parallel combination of a number of capacitors.

Ans: Formula for the equivalent capacitance for parallel combination of capacitors:

In this combination, the capacitors are connected in different branches of the circuit where each plate of a capacitor is connected to positive terminal and other to the negative terminal of the battery.

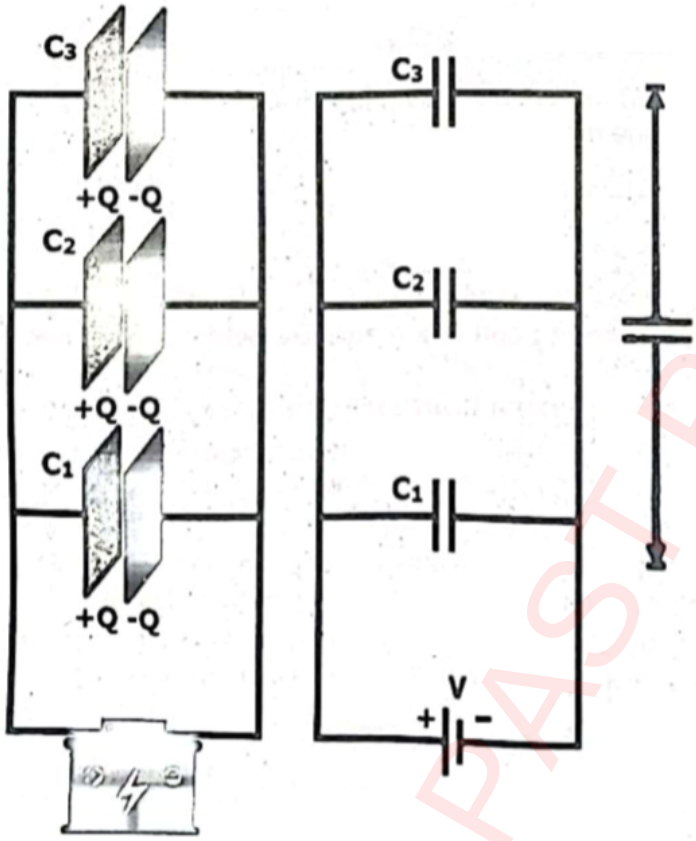
Consider three capacitors, having capacitances C_1, C_2 and C_3, connected in parallel to a power supply of voltage '**V**' as shown in the figure below.

Each capacitor has the same potential difference across its plates given by:

$$V = V_1 = V_2 = V_3$$

The electric charge developed on individual capacitors will be different from each other whose sum will be equal to the total charge of the circuit, given by:

$$Q = Q_1 + Q_2 + Q_3 \quad \ldots\ldots\ldots\ldots (1)$$



PARALLEL COMBINATION

The equivalent capacitance will be greater than the individual capacitors, which is calculated as follows:

The capacitance of a capacitor is given by: $Q = CV \quad \ldots\ldots\ldots\ldots (2)$

Putting equation 1 in 2:

$\Rightarrow \quad C_{eq}V = C_1V + C_2V + C_3V \quad \Rightarrow \quad C_{eq}V = V(C_1 + C_2 + C_3)$

Hence: $C_{eq} = C_1 + C_2 + C_3 \quad \ldots\ldots\ldots\ldots (3)$

For "n" number of capacitors connected in parallel, the equivalent capacitance will be given by:

$\Rightarrow \quad C_{eq} = C_1 + C_2 + C_3 + C_4 + C_5 + \ldots\ldots\ldots + C_n \quad \ldots\ldots\ldots\ldots (4)$

From equations (3) and (4), it is clear that in parallel combination the equivalent capacitance is always greater than any individual capacitance in combination. That's why parallel combination of capacitors is used when we need a greater capacitance than the available.

b. An electric bulb is marked with 220 V and 100 W. Find the resistance of the filament. If bulb is used 5 hours daily, find the energy in kilowatt hours consumed by the bulb in one month (30 days).

Ans:

- **Given data:**

  $V = 220\ V \quad ; \quad P = 100\ W$

- **Required:**

  Resistance $= R = ?$; Energy $(kWh) = ?$

- **Solution:**

$\Rightarrow \quad P = \frac{V^2}{R} \quad \Rightarrow$ Rearranging the formula to solve for R. $\Rightarrow \quad R = \frac{V^2}{P}$

Putting values $\quad Resistance = R = \frac{(220\ V)^2}{100\ W} = \frac{48400}{100} = 484\ Ohm$

Now, we can calculate the energy consumed by the bulb. Using the formula,

$$\text{Energy (kWh)} = \frac{\text{Power (W)} \times \text{Time (hours)}}{1000}$$

Given that the bulb is used for 5 hours daily and there are 30 days in a month, we can calculate the energy consumed in one month.

$$\text{Energy (kWh)} = \frac{(100\ \text{W}) \times (5\ \text{hours} \times 30\ \text{days})}{1000}$$

$$\text{Energy (kWh)} = \frac{100 \times 5 \times 30}{1000} = \frac{15000}{1000} = 15\ \text{kWh}$$

Q5. a. Explain that a current carrying coil in a magnetic field experiences a torque. Also draw a labelled diagram.

Ans: **TURNING EFFECT (TORQUE) ON A CURRENT CARRYING COIL IN A MAGNETIC FIELD:**

When a current carrying coil or loop (for example rectangular coil) is placed between opposite poles of strong magnet we will find turning effect (torque) due to the net force on it.

Explanation:

The resulting torque due to this couple rotates the loop, and the magnitude of the torque acting on the loop is proportional to the magnitude of the current passing through the loop.

Consider a rectangular coil having four sides (**a**, **b**, **c** and **d**) of length **'L'** and width **'W'** carrying current **'I'** in the presence of a uniform magnetic field **'B'** directed parallel to the plane of the loop as shown in figure below.

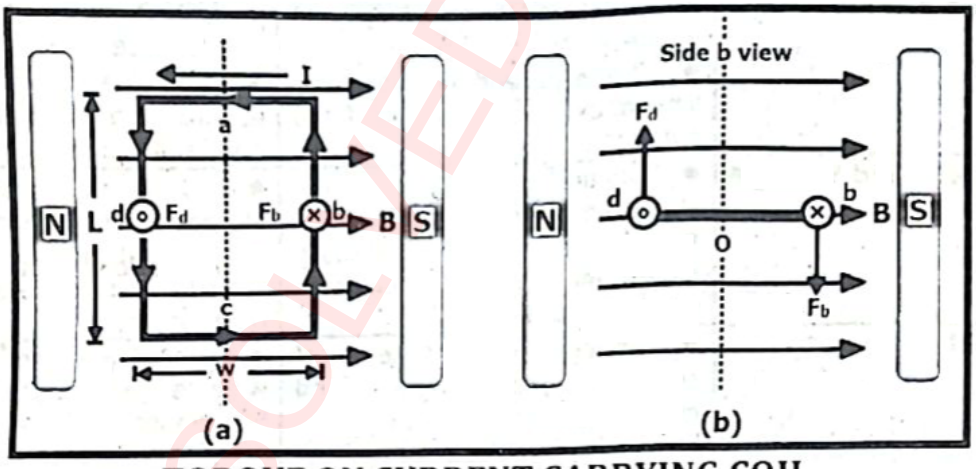
No magnetic forces act:

No magnetic forces act on sides (a and c) of widths **'w'**, because these wires are parallel to the field ($\theta = 0^o$).

Therefore, magnetic force 'F_a' and 'F_c' is: $F_a = F_c = I\,W\,B \sin\theta$

$F_a = F_c = I\,W\,B \sin 0^o \quad \Rightarrow$ Since, $\sin 0^o = 0$

$$F_a = F_c = 0 \qquad \ldots\ldots\ldots\ldots (1)$$



TORQUE ON CURRENT CARRYING COIL

Maximum Magnetic force:

However, maximum magnetic force acts on sides (**b** and **d**) of lengths **'L'**, because these sides are perpendicular $\theta = 90^o$ to the field, therefore magnetic forces on these sides are:

$F_b = F_d = I\,L\,B \sin 90^o \quad \Rightarrow$ Since, $\sin 90^o = 1$

Therefore, $F_b = F_d = I\,L\,B \qquad \ldots\ldots\ldots (2)$

If we view the coil from side **'c'**, we see that, the two forces 'F_b' and 'F_d' are acting on sides **'b'** and **'d'** points in opposite directions such that they can rotate the coil about point **'O'** produce turning effect in the coil (in this case clockwise) as shown in above figure.

Note: If we increase the number of loops, the turning effect is greatly increased. This is the principle involved in electric motors

$\tau = IBA\ Cos\alpha \quad \Rightarrow \quad$ Where τ = torque

I = Current $\quad \Rightarrow \quad$ B = Magnetic field

A = Area of coil

Cosα = The field makes an angle with the plane of coil

b. What are analogue and digital quantities? How can the Analogue Electronics and Digital Electronics be compared?

Ans: Analogue and Digital quantities:

Analogue quantities	Digital quantities
Analogue quantities have continues values, therefore analogue signal is a continuously variable electrical or physical quantity.	Digital quantities have discrete values that represent numbers, letters, or symbols. Therefore digital signal deal strictly with ON and OFF states, which we can represent by 0s and 1s.
Analogue physical quantities involve electric fan, refrigerators, iron, lamp, loudspeaker and radio receivers.	The devices based upon digital physical electronics are computer, TV, security system, mobile phone, digital camera radar system, naval system, medical equipments etc.

Comparison of Analogue and Digital Electronics:

	Analogue Electronics	Digital Electronics
i. Representation	• Uses continuous signals. • Signal values are represented by an infinite set of possible voltage levels. • Analog devices are designed to process and manipulate continuous signals.	• Uses discrete signals. • Signal values are represented using a finite set of discrete levels (usually binary: 0 and 1). • Digital devices process and manipulate information in the form of binary code.
ii. Precision and Accuracy	• Susceptible to noise and interference. • Precision and accuracy are limited by the resolution of the components.	• Less susceptible to noise and interference. • Provides high precision and accuracy due to the discrete nature of signals.
iii. Processing and Storage	• Continuous processing and storage of information. • Analog signals are not easily stored and may require complex methods.	• Discrete processing and storage of information. • Digital signals are easily stored and processed using binary code.
iv. Flexibility	• Limited flexibility in terms of signal processing and manipulation.	• Highly flexible and allows for a wide range of signal processing techniques. • Easily adaptable to different applications through programming.
v. Examples	• Analog audio signals in traditional music systems. • Continuous voltage levels in analog circuits.	• Digital audio signals in modern music systems. • Binary code in computers and digital communication systems.